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A Framework for the Design of a Mobile-Based Alert System for Outpatient Adherence in Nigeria

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ABSTRACT
Nigeria ranks among the countries with the highest child and maternal mortality rate. Chronic diseases are the most common contributors to the diseases burden in Nigeria most especially Malaria, Tuberculosis (TB) and HIV/AIDS. Adherence to long-term therapy in out-patient condition is required to reduce and curb the prevalence of these diseases. Poor adherence to long-term therapies severely compromises the effectiveness of treatment; making this a critical issue in population health both from the perspective of quality of life and of health economics. This work introduces a m-technology based system that will provide an easy way of complying with drug regimen. It will make use of the Short Messaging Service (SMS) of mobile phones to provide reminders at dosing times. It will design architecture for mobile health interventions and develop a prototype SMS-based system to improve out-patient adherence. This system will be deployed over a period of time at selected hospitals and chronic disease management centers in selected states in Nigeria, and the adherence rates measured via health outcomes and evaluated. This would provide a significant positive return on investment through primary prevention (of risk factors) and secondary prevention of adverse health outcomes. It will also inform predictions of future population health outcomes predicted by treatment efficacy data.

Keywords: out-patient, m-technology, adherence, chronic diseases, Nigeria, SMS

1. INTRODUCTION

In conventional medication monitoring, the doctors only can monitor their patients if they are in the ward. The nurses give the medication on time and make sure the patients take the medication. While the patients are out of hospitals, the doctors have no efficient or reliable methods to monitor their patients and make sure the medications are taken as prescribed and on time. Usually, people do not follow their physician's instructions because of their hectic lifestyle due to their family and work at their office. Moreover, they thought that they have already recovered and do not need to take the medication anymore. Thus, they simply forget or just ignore their medication. Another case is when the patients adjust the dosage of their medication without consulting their physician.

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Many people, particularly those with chronic ailments, feel a need to take control of their problem and therefore they try to do so by taking control of their medication dosage. The desire for an increase in the quality of health care is now a global issue. Prescription medications are the core of most medical treatments. Inappropriate or unjustified prescribing and monitoring practices have already begun to receive policy attention managed-care and institutional environments [Fleurant, 2008]. Medications and their correct usage are considered as the most valuable and cost-effective component of acute and chronic medical management of disease [Cheng et. al., 2009]. Unfortunately, many patients do not take them as directed. The terms that define this phenomenon are ***non-compliance*** and ***non-adherence***, both of which refer to the extent to which a person's behavior (in terms of medications and lifestyle changes) coincides with medical or health advice.

This paper introduces Mobile Med Alert, a mobile medical alert system that sends SMS to patients, prompting them to take their drugs. Patients receive alerts on drug intake methods, description and dosages, in order to ensure compliance to drug regimen.

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Furthermore, patients can reply SMS alerts indicating whether they have taken the drugs or not. An incremental approach to software development is used for the development of the system. This approach allows a system to be decomposed into a number of components, each of which are designed and built separately allowing each component to be delivered to the client when it is complete. This allows partial utilization of product and avoids a long development time [Pfleeger, and Atlee, 2006].

2. RELATED WORKS

2.1 Mobile Telephony in Nigeria

A breakthrough in telephone infrastructure emerged in January 2001 when the sector was totally liberalized with the licensing of MTN and ECONET (currently Celtel) mobile phone Company. Over a million lines were injected into Nigeria within a year. Globacom also came into existence in 2003. Several years down the line, the growth of telecommunication industry in Nigeria has been reasonably fast. More operators have been licensed, different service packages are available and some operators now provide combined internet services [Omitola et. al., 2009]. The Global System of Mobile Communication (GSM) is spreading in a highly competitive manner and has enhanced the exchange of information especially in Nigerian teaching hospitals. As at May 2012, the Nigerian Communications Commission (NCC) has 118,850,928 connected GSM lines, of which 97,553,425 GSM lines are active [www.ncc.gov.ng]. Today, the GSM and other telephony services have revolutionized telecommunication in Nigeria with impacts in every sector including social, economic and health [Idowu et. al., 2008].

2.2 Existing Systems and Related works

A wide variety of approaches have been proposed to help patients to complete prescribed treatments. For example, medications are often packaged with reminder systems for the day and/or time of the week to take the prescribed medicine. Some of these reminder systems have been integrated into portable telecommunication devices such as the mobile phones. Short Message Service (SMS) is a text communication service component of phone and has been reportedly used in the field of medicine. It has been used for patient reminders, psychological support, reporting of critical medical events or laboratory results and' also chronic disease management [Yudan et. al., 2008]. Many projects have applied wireless technology in ensuring patient adherence. Such pilot projects include: the WelTel Kenya1 project, a randomized trial of mobile (cell) phone text-messaging to improve patients' adherence to antiretroviral therapy [Lester et. al., 2010]; Disease Management Assistance System (DMAS), a programmable electronic device that provides verbal reminder messages at dosing times [Wu et. al., 2006]; Computerized Automated Reminder Diabetes System (CARDS), an e-mail and SMS cell phone text messaging reminders to support Diabetes management [Hanauer et. al., 2009]; Project Masilukeke in South Africa takes advantage of the 120 spare characters on free "please call me" SMS messages to provide HIV/AIDS education and awareness [www.newsvote.bbc.co.uk/2/hi/technology/7688268.stm].

In Norway, SMS messages are sent to educate parents with Type 1 diabetic children. These messages included definitions, facts and tips for managing diabetes [Wangberg et. al., 2006]. Text to Change (South Africa) project employs an SMS-based quiz to test users' knowledge of HIV/AIDS and encourage testing and counselling [http://texttochange.com]. Wedjat is a mobile medication reminder and monitoring system. It is a smart phone application designed to help remind its users to take the correct medicines on time and record the in-take schedules for later review by healthcare professionals [Wang et. al., 2009].

Ikhu-Omoregbe and Azeta (2010) designed and implemented a Voice-based Mobile Prescription Application (VBMOPA) to improve health care services. The application can be accessed anyplace anytime, anywhere through a mobile phone by dialing an appropriate number, this connects users to an e-prescription application that is resident on a web server.This system could lead to costs and life savings in healthcare centres across the world especially in developing countries where treatment processes are usually cumbersome and paper based.

Since the launch of Nigerian mobile telephony in 2001, the use of mobile phones in Nigeria has increased [Adomi, 2005] and the average Nigerian has access to a mobile phone including medical experts and professionals. Some areas where mobile phones have been particularly useful include the contacting of wards and laboratories for vital information, materials and equipment, calling on colleagues for second opinions. They have also been used for communication between the wards such as for patient referrals from one ward to another and to reach other physician in emergency cases. However, these physicians had to use their personal phones without any form of reimbursement from government or hospital management. There is a significant improvement in this situation as the management of some hospitals have now taken up the responsibility of providing and funding the facilities [Omitola et. al., 2009]. Recently, the Ondo state government launched an initiative that is using mobile phones to save the lives of indigent pregnant women. The project tagged "**ABIYE**: Safe Motherhood" is supported by the World Bank [Sunday Punch; December 25, 2011]. This initiative targets the reduction of maternal mortality, one of the major health challenges in Nigeria, especially in Ondo state. The program, piloted in Ifedore aims to get past the obstacles that prevent expectant mothers from low-income families from seeking help during pregnancy.

To begin with, the government conducted a mass registration of pregnant women like sensitizing communities about the importance of staying healthy during pregnancy, but also raising awareness among them about the services available to them. Registered women were given cell phones with toll-free access to 'Health Rangers', health facilities, or even the Governor himself, who has received many a call from a woman surrounded by an excited household [http://web.worldbank.org/] .

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2.3 The need for m-Technology-based Intervention

It is certain that ICT has contributed to the positive growth of health care delivery systems in major hospitals in Nigeria. Most healthcare providers believe that improvement in telecommunication within the hospitals is capable of improving the quality of care. They believe that intercommunication between patients and care givers as well as among care givers can be especially improved [Omitola et. al., 2009]. For example, up to 68% of post-surgical patients have been effectively followed up using their GSM phone contacts [Mbah, 2007]. This observation beams a ray of hope as it appears that with increasing availability of mobile phones and extension of connectivity to the rural areas, the problem of difficult patient follow-up which has been the bane of longitudinal study design in Nigeria may be over soon. The use of telephone to schedule clinic appointments is also emerging, particularly more prominently in University College Hospital, Ibadan (UCH).

This is also a useful aspect which must be encouraged in all the hospitals, considering the enormous benefit derivable from such practice which includes overall reduction in time wastage and its economic consequence [Omitola et. al., 2009]. Another area where significant improvement is being recorded is in the interaction between patients and physicians. The benefits range from scheduling and rescheduling of appointment dates, individualized time schedule to reduce waiting time in clinics and so control patient load per clinic hour, and prioritization of patients based on exigency of needs. Since mobile phone has already become a common tool in the hands of the public, incorporation of medical services can help to maximize the potential for improved health care.

2.4 m-Technology and Patient Compliance

People saddled with chronic diseases need recommendations or facts regarding disease management. These include dosage adjustment of medication and other general information that highlights correction of life styles, changes in diet and physical exercise. The ubiquity of mobile phones and its current integration in health care has made it a worthy tool to this effect. What this project proposes is simple. Through SMS technology, patients can be alerted of medications and other information pertaining to their health. Also, the patient can respond and confirm his compliance to drug regimen. Hence, chronic diseases can be thereby monitored effectively and conveniently, improving both patient's health status and health care delivery**.**

3. DESIGN ARCHITECTURE

Mobile Med Alert was developed using programming tools such as extensible hypertext markup language (xHTML), hypertext processor (PHP), MySQL and the integration of Ozeki SMS gateway. Its main features includes: it can alert patients about potential drug in-take at a scheduled time, in accordance to drug regimen; it allows for feedback mechanism whereby the
Patient can respond appropriately to alert messages. In both cases, the application aims at increasing patients' compliance to treatment and in the long run, reduces the rate of non-compliance in relation to drug regimen.

The system administrator enters information about medication to be taken by the patients. At a pre-determined time for drug in-take, the PHP application inserts a row with the data of the SMS to be sent. This will be selected by Ozeki NG - SMS Gateway from the database. Ozeki NG will forward the message to the GSM network through a mobile phone attached to the Personal computer (PC) with a data cable to the recipient. The patient on receiving the SMS will send a feedback indicating if he has taken the drug or not. The feedback goes through the network, to the mobile phone attached to the PC and into the data store for subsequent reviews.

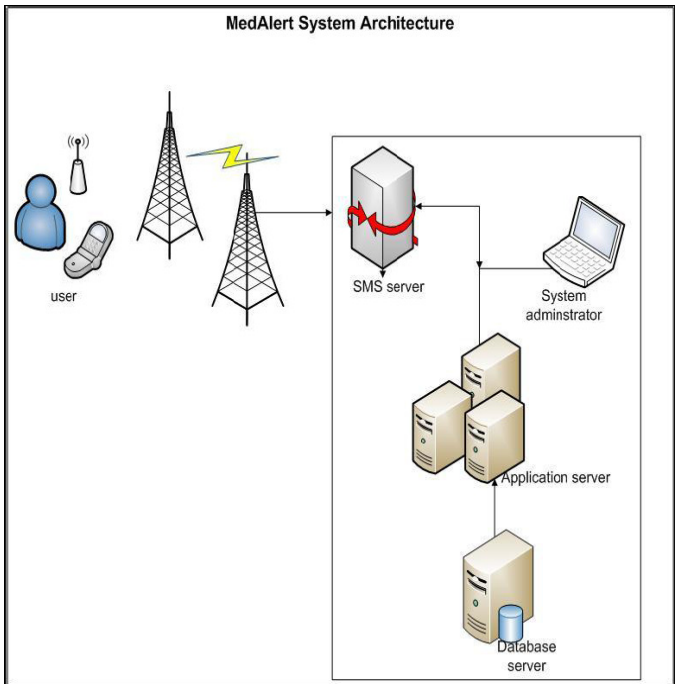

Figure 1: Mobile Med Alert System Architecture

SMS scheduler function of Ozeki NG SMS Gateway allows message correspondence to be handled in a timely manner. The solution includes specifying the exact time for later sending of SMS messages. The great advantage of the scheduler is that it allows sending of multiple messages to multiple recipients and these messages can be saved and scheduled separately. This function allows reminder messages to be prepared and scheduled for delivery at the specified time for the drug in-take

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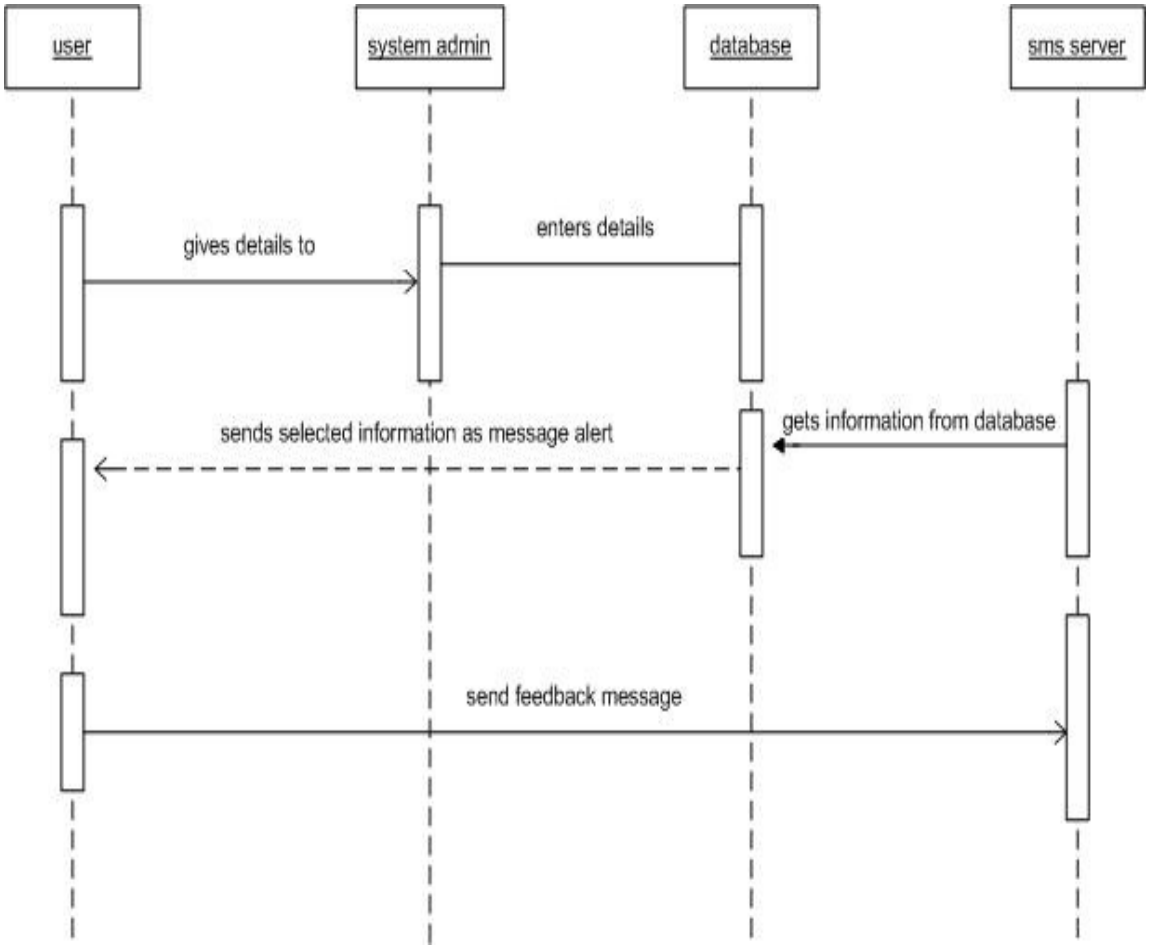

Figure 2: Sequence Diagram

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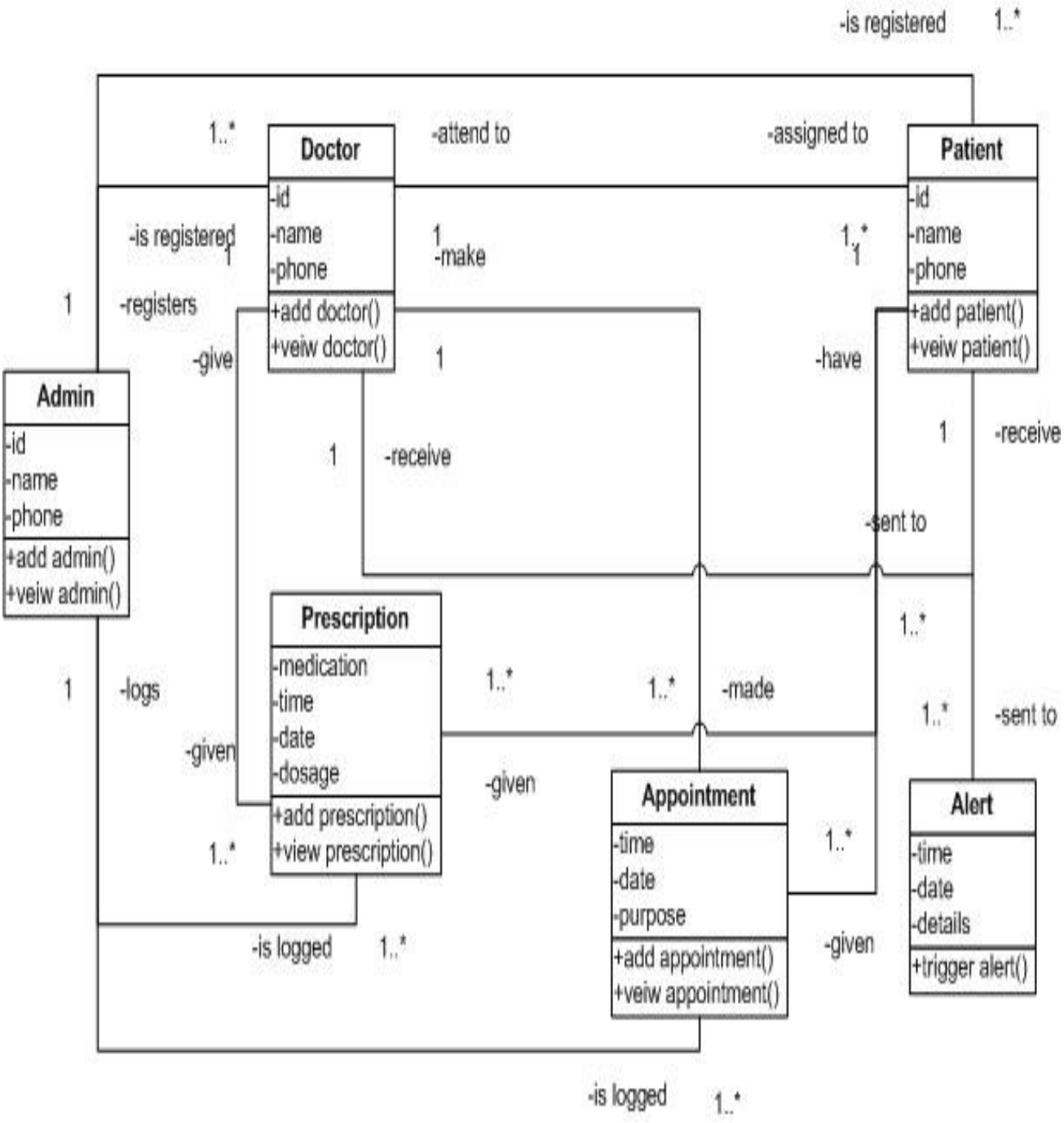

Figure 3: Class Diagram

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4. DISCUSSION

Mobile Med Alert is a mobile phone application that aids the user in remembering drug times and dosages. It employs the use of Short Messages Service (SMS) to send reminders to patients so as to enhance compliance to drug regimen. Information collected from the user is stored by the healthcare personnel in the database.

Figure 4: Home Page of Mobile Med Alert

The application goes through the data collected in search for a set drug time that corresponds with the current system time. Once found, the application sends a reminder to the stated recipient, reminding him to take his drugs while prompting him to reply the text message. The need for responding to the text messages is to allow for feedback. Feedback is very important as it not only fosters patient-doctor relationship, thereby increasing the quality of healthcare delivery. It is also provides a means for doctor's to adequately monitor patients even when they have been discharged from the hospital. Both the outgoing and incoming messages are stored in the log for subsequent reviews by healthcare personnel. As an added functionality, patients can also be reminded of medical appointments with their doctors. The user receives information about drug time and dosages on his mobile phone and is able to check his appointments, prescription and can also edit his information if need be. Depending on the set interval, the patient will always receive medication alerts until the set number of times has been used up after which the prescription is deleted.

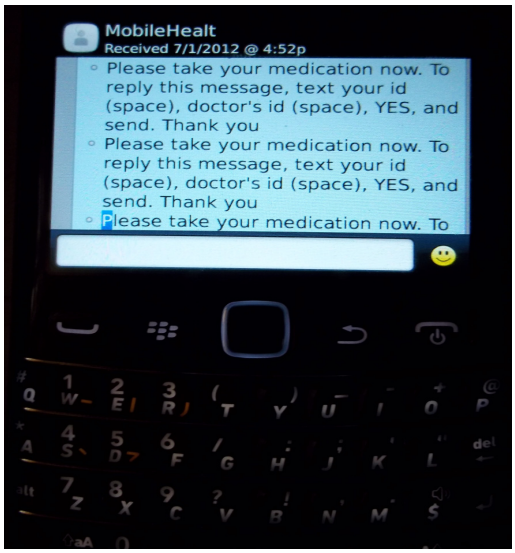

Figure 5: Screenshot of Reminder on Patient's mobile phone

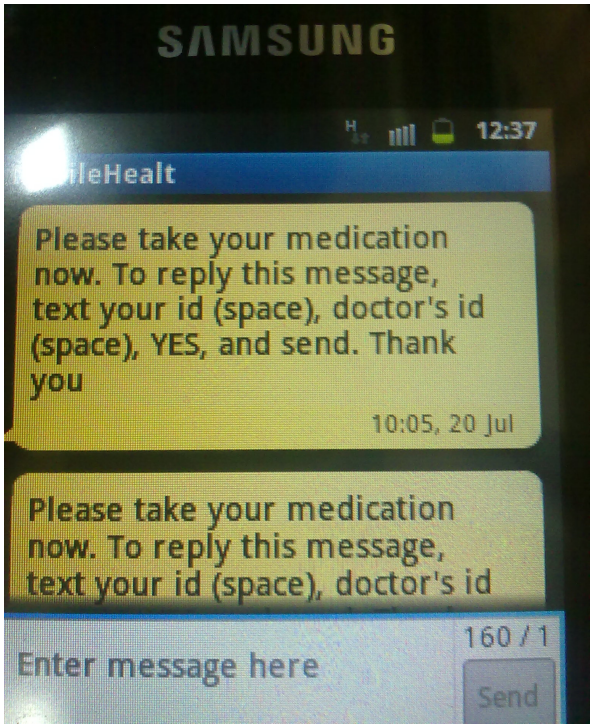

Figure 6: Screenshot of Reminder on Patient's mobile phone

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Figure 7: Screenshot of Patient's Prescription page

Figure 7: Screenshot of Patient's Feedback (response) to Reminder page

5. SIGNIFICANCE OF THE WORK

Carrying out this research in rural areas of Nigeria will be of great significance. It will help to cater for the shortage of health workforce in these areas, hence, reduce mortality and morbidity. It will significantly reduce epidemics in these areas. The health outcomes, when measured will determine the effectiveness, feasibility and acceptability of wireless technology in improving patient adherence to long-term therapy in Nigeria. These health outcomes will inform planning and project evaluation.

6. SUMMARY AND CONCLUSIONS

Currently, this research is at the development phase and further work will be to deploy and evaluate the prototype application within the scope of HIV/AIDS patients in Nigeria. This will be done following set evaluation standards and procedures. HIV/AIDS patients need recommendations or facts regarding disease management. These include dosage adjustment of medication and other general information that highlights correction of life styles, changes in diet and physical exercise. The ubiquity of mobile phones and its current integration in health care has made it a worthy tool to this effect. Through SMS technology, patients can be alerted of medications and other information pertaining to their health. Also, the patient can respond and confirm his compliance to drug regimen. Hence, they can be monitored effectively and conveniently.

It is expected that this research will bring about an increase in compliance to drug regimen, improve health status of patients and also improve healthcare delivery.

REFERENCES

[1] Adomi, E. (2005), "Mobile Telephony in Nigeria." Library Hi Tech News, 22(4), 18-21.

[2] Fleurant, M., (2008), "High-Tech, Simple Solutions For Improving Patient Care Management," Journal of Biotechnology Healthcare Sep–Oct; 5(3): 35–38.

[3] Wang, M., Tsai, P.H, Liu, J.W.S, Zao, J.K (2009), "Wedjat: A Mobile Phone Based Medicine In-take Reminder and Monitor," bibe, pp.423-430, in *Proceedings of the Ninth IEEE International Conference on Bioinformatics and Bioengineering,* 2009

[4] Cheng, P. H.; Lai, F.; Lai, J.-S. (2009), "A Service-Oriented Healthcare Message Alerting Architecture in an Asia Medical Center: A Case Study." **Int. J. Environ. Res. Public Health 2009**, **6**, 1870-1881.

[5] Vaishnavi, V. K., Kuechler, W. J. (2004), "Design Research in Information System" Retrieved Jan 20, 2010, from http://www.isworld.org/Researchdesign/drisISworld.htm

[6] WHO Report 2006-Facing the Facts: The Impacts of Chronic Disease in Nigeria.

[7] Yudan M., Yantao Z., Suodi Z. (2008), "Mobile Phone Text messaging for Pharmaceutical care in a Hospital in China," Journal of Telemedicine and Telecare, 14(8).

[8] Lester, R.T. Ritvo, P. Mills, E.J. Kariri, A. Karanja, S. et. al., (2010), "Effects of a Mobile Phone Short Message Service on Antiretroviral Treatment adherence in Kenya (WelTel Kenya1): A Randomised Trial", Lancet 2010; 376: 1838–45, DOI:10.1016/S0140-6736(10)61997-6, www.thelancet.com.

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[9] Hanauer, D.A. Wentzell, K. Laffel, N. and Laffel, L.M. (2009), "Computerized Automated Reminder Diabetes System (CARDS): E-Mail and SMS Cell Phone Text Messaging Reminders to Support Diabetes Management," Diabetes Technology & Therapeutics, 11(2), doi: 10.1089/dia.2008.0022.

[10] Wangberg, S.C. Arsand, E. and Andersson, N. (2006), "Diabetes Education via Mobile Text Messaging," Journal of Telemedicine and Telecare, 2(1):55-56.

[11] World Health Organization. (2003). "Adherence to long-term therapies: Evidence for action. Geneva:Author." Available from www.who.int/chronic_conditions/adherencereport/en accessed on 10/1/2011; 5:00pm.

[12] Idowu, P.A., Ajayi, A.S. (2008), "GSM based Referral System for Primary Healthcare Centers in Nigeria." International Journal of Soft Computing, *3*(6), 421-427.

[13] Omitola, O., Akadiri O.A, Olusanya A.A (2009*),* "Impact of Improved Telecommunication Services on Health Care Delivery in Nigerian Teaching Hospitals – A Survey of Opinions," Journal of Information Technology Impact 9(3), 125-134.

[14] Mbah, N. (2007), "Telephone use for surgical follow up in a developing country." Nigerian Journal of Clinical Practice, 266.

[15] Pfleeger, S.L and Atlee, J.M, " Software Engineering: Theory and Practice," Third Edition, Pearson Educational Inc, 2006

[16] http://www.ncc.gov.ng/industry-statistics/subscriber-data.html (accessed on 16th July, 2012).

[17] Ikhu-Omoregbe, N. A., and Azeta, A. A. (2010), "A voice-based mobile prescription application for healthcare services (VBMOPA)." International Journal of Electrical & Computer Science, 10(2), 73-77. Retrieved from http://eprints.covenantuniversity.edu.ng/12/

[18] *http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/AFRICAEXT/NIGERIAEXTN/0,,contentMDK:22965126~menuPK:50003484~pagePK:2865066~piPK:2865079~theSitePK:368896,00.html*.

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